Technical Paper 83

UNIVERSITY
SEP 8 1915
PRINCETON

DEPARTMENT OF THE INTERIOR
BUREAU OF MINES
JOSEPH A. HOLMES, DIRECTOR

THE BUYING AND SELLING OF ORES AND METALLURGICAL PRODUCTS

BY

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WASHINGTON
GOVERNMENT PRINTING OFFICE
1915

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First edition. June, 1915.

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THE BUYING AND SELLING OF ORES AND METALLURGICAL PRODUCTS.

By Charles H. Fulton.

INTRODUCTION.

The buying and selling of ores and metallurgical products is a great and highly important business in the United States, and one that concerns not only the miner and the metallurgist but the industrial world in general. In this paper the attempt is made to outline clearly its underlying principles, the subject matter being based on personal experience and investigation. The author has endeavored to present the material impartially, and for that reason many of the statements and figures regarding metallurgical practice should be taken as illustrative rather than as applying exactly to average operating conditions. Moreover, the statements as to metal prices and trade methods are to be considered as applying to normal business, not to special conditions that have developed as a result of the war in Europe. As regards the style, technical words and phrases have been avoided as much as possible in order to make the paper easily understood by anyone who might be interested.

In estimating the value of an ore or an intermediate metallurgical product (other than a refined metal) the basis used is the price of the refined metal at some principal market center, such as New York, at the time the valuation is made. The average price of all copper for 1913 was 15.5 cents per pound,[a] and for electrolytic copper 15.269 cents per pound.[b] The prices for other metals for the year 1914 were as follows:[b] Lead, 3.862 cents per pound; spelter, 5.213 cents per pound; silver, 54.811 cents per troy ounce. Gold has the standard value, established by law, of $20.67 per troy ounce.

If the metal contents, in pounds for the base metals and in troy ounces for the precious metals, per avoirdupois ton be multiplied by the prevailing price of the refined metals, the sum of the products will be the gross value of the ore.

There is, however, a wide difference between the gross and the net value of a ton of ore. From the gross value must be deducted, first, the total cost of mining the ore, and then the total cost or charge for treatment, which includes some or all of the following items: Freight to treatment plant, milling or smelting charge, charge to compensate for losses of metal in treatment, charge for penalties imposed on undesirable constituents in the ore, charge for freight to refining center, charge for refining the metal, charge to cover the selling costs of the refined metal. Which of these charges are imposed and what the amount of each charge is depend on the ore, the method of treatment, and the number of firms that handle the ore and metals in the process from ore to refined metal.

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[a] Butler, B. S., Copper in 1913: Mineral Resources U. S. for 1913, U. S. Geol. Survey, 1914.

[b] Engineering and Mining Journal, Jan. 9, 1915.

The types of companies that handle ores and metallurgical products may be classified as follows:

1. Mining and smelting companies or mining and milling companies, which control all the operations from the mining of the ore to the production and selling of the finished metal.

2. Mining companies, which mine and sell ore on certain schedules to smelting or milling companies.

3. Custom smelters or mills which purchase ores and also (*a*) operate refineries and produce refined metals or (*b*) sell intermediate metallurgical products to refineries.

Concerns of type 3 may control mines that furnish a part of their ore supply.

4. Refining companies, which purchase metallurgical products, such as matte, and crude metals, and some ores, and produce refined metals.

5. Selling agencies, which place the refined metals on the market.

It is apparent that an ore or the products derived from it may go through many hands before the finished metal reaches the market, and that metallurgical business may be complex. In the following pages the essentials of the commercial side of metallurgical work are discussed in some detail.

ACKNOWLEDGMENTS.

The author desires to express his obligation to Mr. John T. Milliken, of Colorado Springs, for certain information on the "Milling of Ores," and to Mr. Walter Renton Ingalls for permission to use data in his articles on "How the Metals are Sold."

COMPOSITION OF ORES.

It is most important to know the contents of an ore in gold, silver, copper, lead, and zinc, if any or all of these metals be present. In smelting work such other constituents are determined as may be necessary to make proper smelting mixtures. Analyses of ores are made to determine silica, iron, alumina, lime, and, less often, magnesia, barium, sulphur, and arsenic. Many other substances may be determined as occasion demands.

In gold and silver milling work it is usually unnecessary to make analyses of the ores, except to determine gold and silver, although sometimes it is desirable to know the other constituents of the ores, particularly as regards the presence of elements or compounds such as copper, lead, zinc, tellurium, selenium, sulphur, arsenic, and antimony, that interfere with the extraction of the precious metals. In lead and copper smelting, however, it is essential, in order to control smelting operations, to know within narrow limits the proportions in the ores and flux of silica, lime, magnesia, alumina, sulphur, and iron, aside from the metallic contents for which the operations are conducted. These facts make a chemical or assay laboratory an essential part of a smelter or mill. This laboratory must furnish the requisite data promptly on short notice in order that the technical operations of the plant may be properly guided. Such laboratories daily turn out a great many routine analyses with accuracy and dispatch.

THE SAMPLING, BUYING, AND SELLING OF ORES.

In order that assays and analyses may be of value, the samples assayed must truly represent the lots of ore, the value and composition of which it is desired to know. For this reason it is necessary to sample given lots of ore as they come to the mill or smelter. If ores or metallurgical products, such as matte, pig or blister copper, or lead bullion are sold by one company and purchased by another, accurate sampling is essential. Consequently reliable methods of sampling such products have been devised. If a company both mines and treats its ores, careful sampling may not be necessary, but in most instances will be desirable, in order to verify the technical work and aid in the accounting. In order to facilitate the selling and buying of ore, public sampling and ore-purchasing companies have been established. Such a company acts as a disinterested party between buyer and seller, sampling the ore for a fixed charge per ton.

PRACTICE AT CRIPPLE CREEK, COLO.

As an example of how transactions in ore are conducted, the practice at Cripple Creek, Colo., may be cited. The shipper who sends his ore under contract to a milling company has the right to sample his ore in any of the public sampling works at his own expense. He may then either sell the ore to the sampler, who buys it under the milling company's contract rates, or he may reconsign it to the milling company direct, where it is again sampled, the results of this sampling becoming the basis of settlement for the ore. In any event all ore passing through the sampling works on contract must go to the mill holding the contract. Ore that is reconsigned and not purchased by the sampling company is sampled for 60 cents a ton, but if it be purchased by the sampling company the charge is $1 a ton. As to ore not under contract, the owner has the choice of either selling it to the public sampling works or shipping it directly to the mills or smelter.

The deductions for treatment made by a sampling company are governed in every instance by those quoted by mills and smelters, as the sampling company has no other outlet for the purchased ore. Public sampling companies give the ore shipper the advantage of having his ore sampled in the camps and purchased by the sampler under mill or smelter contract and of receiving his money several days earlier than if he ships directly to the mill or smelter.

By reason of the fact that the public sampling companies have no other outlet for ores purchased than the mills or smelters, it is obvious that such companies are more or less governed by the methods employed by the smelters and mills. This statement applies generally throughout the West to the sampling of gold, silver, lead, and copper ores. The real function of the public sampling works is to aid the miner and the smelting and milling companies.

There are public sampling works at Cripple Creek, Georgetown, Idaho Springs, and Central City, Colo.; in the vicinity of Salt Lake City, and at Ogden, Utah; at Millers and Hazen, Nev.; at Butte, Mont.; and at San Francisco, Cal.

SAMPLING OF ORES BY MILLING AND SMELTING COMPANIES.

All well-regulated custom milling and smelting companies maintain their own sampling departments. The ore received is sampled and the results obtained form the basis on which the ore is purchased. This procedure is strictly followed whether the ore has been sampled once or a number of times before being shipped to them.

At present the general attitude of the ore seller, in regard to sampling, appears to be one of satisfaction. Occasionally, of course, some individual shipper complains, but in general complaints are not common.

The facilities afforded by the public sampling companies and the mills and smelters for the sampling of all classes of ore have been developed to a high degree of efficiency.

METHOD OF SAMPLING ORES.

No mill or smelter can treat each lot of ore separately. Such a procedure would be impossible because of cost and of technical difficulties. If separate treatment were possible, sampling might be unnecessary, for then the product of the operation on a given parcel of ore, or the value of the ore, could be turned over to the seller. But as this procedure is impossible the only method of determining the amount of valuable metals in the parcel of ore is by sampling, as above outlined.

Sampling formerly done by hand labor and by crude methods, often inaccurate, is now largely done by automatic machinery. A considerable part of the ores sampled by mechanical means is usually crushed fine. Such crushing is undesirable if the ore is subsequently to be smelted in the blast furnace. For this reason lead-smelting plants, which must treat all ore, whether coarse or fine, by blast-furnace smelting, still practice the so-called hand sampling of oxide ores. The ores received by the lead smelter are broadly divided into two classes, sulphide ores and oxide ores. The sulphide ores, which must first be roasted and sintered (agglomerated) before smelting, are of necessity crushed fine, in order to facilitate roasting. The oxide ores, however, need not be crushed fine. It is customary, therefore, for lead-smelting plants to have a sulphide-sampling mill in which the sampling is conducted by standard mechanical means and an oxide-sampling mill where the sampling is done largely by the alternate-shovel method and by coning and quartering, in which only a relatively small part of the ore is crushed

The charges for the sampling are comparatively small (25 cents to $1 per ton) and are no burden in return for the benefits received.

The final sample is a small part of the original lot of ore; perhaps 1 part in 60,000 to 30,000. The final sample is usually divided into 4 equal parts, which are placed in paper sacks and distributed to the interested parties, one being retained for reference. Glass bottles, instead of paper sacks, are used for sample containers by some companies.

The practice followed in settling for ores after the metallic content has been ascertained is to split the results of the assays of the shipper and purchaser according to a previously arranged plan. On a gold ore, for example, assaying between 1 and 2 ounces, the practice is, if there be a difference of two to five points (0.02 to 0.05 ounce), to take the average, or "split the difference," of the two assays. If the ore contains 2 ounces or over, the allowance is 4 points (0.04 ounce), the purchaser and seller splitting this difference. If the purchaser's and seller's assays do not agree close enough to permit splitting the difference, a sample is submitted to some reliable independent assayer for an "umpire" determination. Should the result of the umpire fall between that of the two disagreeing assays, his assay is taken as the basis of settlement, the interested parties sharing in the cost of the umpire's services. On the other hand, should the umpire assay be lower or higher the assay result nearest the one obtained by the umpire is then taken as the basis of settlement, and the cost of the umpire is paid by the one whose assay results were rejected.

The umpire assayer is usually chosen by agreement between the ore buyer and the ore seller. In drawing ore contracts specifying the terms under which ore is bought it is customary to name three reliable assayers of reputation, satisfactory to both parties of the contract, from which the umpire assayer for any particular lot of ore may be selected. Frequently the ore purchaser, either a smelting or a milling company, pays the umpire, irrespective of whether the cost be assessed against the buyer or the seller of the ore. If the seller is liable for the cost, this is deducted on his "settlement sheet," which gives the net return on his lot of ore. Umpire assayers are sometimes criticized by the sellers of ore on the basis that no umpire assayer could exist in business if he incurred the displeasure of smelting and milling companies, as such companies receive so many parcels of ore and thus control so much umpire work that their displeasure would mean a large loss of business to the umpire. The suggestion has been made that some central authoritative board of umpires be created to finally adjudicate disputed cases.

MOISTURE IN ORE.

Smelting and milling charges are practically always based on "dry weight," and assays and analyses on dried samples. The ore as mined and shipped always contains a certain amount of water as "moisture." The water in the ore may be present in two forms—as moisture or mechanically contained water; and in some instances in part as chemically combined water or "water of crystallization," this water entering into the chemical constitution of some minerals, such as kaolin and alunite.

The ore may be rather wet when mined or may become wet in transit from mine to reduction plant. Although water of crystallization is a fixed unvariable quantity and is part of the ore, "moisture" is a variable quantity, its fluctuations depending on the wetness of the mine and on weather conditions. Assays and analyses of two undried samples of the same ore rarely agree, as one of the samples may undergo some drying in transit and for this reason give higher results per unit weight than the wet sample assayed at once at the mine where it was taken.

The practice therefore is to weigh the ore at the sampling plant immediately before sampling. This weight is called the "gross weight" of the ore. Then the ore is sampled, the sample is weighed and is dried in a steam bath at about 212° to 250° F., until the moisture is driven off. The weight is determined and the percentage of moisture removed is calculated. Deducting the calculated moisture from the gross weight gives the "net weight" of the lot of ore to which the metal content of the dried sample corresponds. The temperature of drying is not carried beyond 212° to 250° F., in order that no water of crystallization may be removed. Water of crystallization is not expelled until a higher temperature is reached, and failure to expel all of it introduces another variable. The moisture in ores varies greatly, from about 2 to 30 per cent and more, according to the nature of the ore. Solid, hard, quartzose ore has the lowest moisture content, whereas clayey ore may contain a large percentage. It is evidently to the advantage of the shipper to ship ore as dry as possible, as freight is paid on gross weight and the shipper receives no return for the water content. Water may be and is often absorbed in large quantities by ore shipped in open cars, and the ore must be weighed before sampling, rather than to depend on railroad shipping weights at the point of origin.

It is still a common practice to collect a "grab" moisture sample in addition to the regular sample, by taking indiscriminately a number of shovelfuls from the lot of ore, on the assumption that moisture is lost during sampling and that a moisture determination on the final sample will result in crediting the shipper with too large a net weight. Such a haphazard method of determining moisture is usually inaccurate and should be discarded as unfair. The moisture in ore is chiefly in the fine part, and a "grab" sample may contain an undue proportion of fine material. The moisture lost during the principal sampling operation can be allowed for by a correction. In Colorado experiments[a] have shown that the loss in moisture during machine sampling is about 10 per cent in summer and 7 per cent in winter; that is, ore showing 5 per cent of moisture in the machine sample, actually contains 5.5 per cent during summer conditions. Hence moisture should be determined in the regular sample and the proper correction allowed for.

The moisture content of ores is a frequent source of dispute and discord between buyer and seller, for no direct redetermination or resampling is possible, as is for the metal content, though the ore lot may be reweighed and this weight compared to the original wet weight and the percentage of moisture arrived at in this way.

ASSAYS AND ANALYSES.

As already stated, all such assays for gold and silver and other precious metal, and all such analyses for copper, lead, zinc, and other substances as may be necessary, are made on the dried sample. The precious metals, gold, silver, and platinum, are determined by means of the fire assay, and other metals and constituents by wet chemical analysis. The fire assay for gold, silver, etc., can be made with great accuracy, so that in the regular commercial work carried on daily in assay laboratories, 1 part gold in 3,000,000 parts ore, and 1 part silver in 300,000 parts ore are readily determined. One part gold in 2,916,660 parts ore represents 20 cents in a ton of ore. Assays of samples must agree within 20 to 60 cents in ores not exceeding $40 in value; a greater difference is permissible for higher grade ores. Silver is usually required to check within one-half to 1 ounce per ton. The troy ounce is the standard by which all precious metals are sold. The standard weight of ore in the United States is the avoirdupois ton of 2,000 pounds. The relation between troy and avoirdupois weight is found in the figures that 1 ton avoirdupois contains 29,166.6 troy ounces.

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[a] Brunton, D. W., Modern practice of ore sampling: Trans. Am. Inst. Min. Eng., vol. 40, 1909, p. 567.

The assayer, therefore, adopts as a unit weight in the laboratory the assay ton, which contains 29,166.6 milligrams, equal to 29.166 grams. With this standard weight of ore taken as a sample, every milligram of gold recovered therefrom represents an ounce troy per ton avoirdupois of ore. Assay balances weigh readily to 0.005 milligram, so that the determination of gold to 0.01 milligram, equivalent to 0.01 ounce, or 20 cents gold, is not difficult. Accuracy may be increased by taking sample weights that are multiples of the assay ton.

In the British Colonies gold is estimated in ore as ounces, pennyweights, decimal parts of a pennyweight, and also as grains per ton of 2,000 and of 2,240 pounds; in Mexico, as grams per metric ton, (2,204.6 pounds) or as grains per short ton, or as ounces per short ton as in the United States. Copper, lead, zinc, and other constituents are determined as percentages. Thus, copper ore containing 10.10 per cent copper will contain 202 pounds of copper per ton. One per cent per ton, equivalent to 20 pounds, is frequently termed a unit, and payment for copper and lead is sometimes made on the unit basis. In commercial work the metals are usually determined to within 0.05 to 0.20 per cent, although sometimes greater accuracy is required. Other substances in the ore, as silica, lime, iron, and alumina, the amounts of which must be known in order to direct technical operations, are determined by rapid methods, some of which are only approximate, yielding results correct to 0.1 to 1 per cent, although others give more accurate results.

A common determination made at smelters is termed "insoluble," and is the weight of the residue left after treatment of the sample with hydrochloric and nitric acid. This insoluble consists largely of silica, and is frequently considered equivalent to a silica determination. However, in addition to silica, it may contain a considerable proportion of alumina and other insoluble constituents of the ore. Sometimes, on the other hand, the insoluble does not contain all the silica, part of it having gone into solution. On the whole, the so-called insoluble determination is unsatisfactory both for guiding the technical work of the plant and to the ore seller. This method is especially unsatisfactory to the seller when the proportion of the insoluble is unduly high, and a silica penalty is exacted in the treatment of the ore. In the regular analytical work, performed at the smelting plants to guide the technical operations of the plant and to furnish data for settlement on ores, both the insoluble and the silica are determined. The insoluble determination is used for determining silica penalties and bonus for iron in ores in making settlement with the seller, and the silica determination is needed to guide the operation of the furnaces.

The silica content is almost invariably lower than the insoluble. This difference is as much as 15 to 20 per cent in many ores high in insoluble content, and differences of 4 to 6 per cent are frequent.

The limits within which the assays on gold and silver made by the seller and the purchaser of the ore must agree have been discussed. In contracts examined by the author, the limits within which the analyses of various other metals agree are as follows: Copper, 0.25 to 0.50 per cent; lead, 0.50 to 1 per cent; zinc, 1 per cent; insoluble, 1 to 2 per cent; lime, 1 per cent; iron, 1 to 2 per cent.

FREIGHT RATES.

The freight rates on an ore from mine to smelter or mill necessarily differ greatly in different districts. They are usually based on distance and on ore value; that is, a base rate is made on a certain grade of ore, and an additional charge is made for a certain increment in value, so that the highest grade ore pays the highest rate for freight. This system of rates is based on the assumption that, as the railroad company is responsible for loss in transit, risk on high-grade ore is greater than on low-grade ore, and also that the more valuable ore can bear a comparatively higher freight rate, an increase in rate that is in part remitted by the lower rates on less valuable ore. The general effect is to stimulate the mining of low-grade material that might otherwise be wasted. The following table shows the relation of freight rates in Colorado to the value of the ore:

Freight rates on ore from Cripple Creek, Colo., to Colorado City, Colo., and vicinity.

Value of ore.	Rate per ton.
$20 and less	$1.00
$20 to $25	1.25
$25 to $30	1.50
$30 to $40	2.00
$40 and more	2.50

METAL ACCOUNTING.

In every smelter or mill a metal account is kept that shows the quantity of metal in ores passing into the plant, and also the quantity shipped from the plant, either of intermediate metallurgical products or of finished metals. Such an account is essential in order that the business may be conducted intelligently and that avoidable losses may be stopped. No metallurgical process recovers all the valuable metal in the ore, as certain losses, such as the metal in slags, in the tailings or refuse matter in milling, or that lost by volatilization in smelting, are unavoidable. In order to keep a satisfactory metal account, it is necessary to know the exact dry weight of all ores entering the plant and their metallic content as determined by assay and analysis of representative samples of the ore lots.

It is evident, therefore, that the receiving, weighing, sampling, and assaying of the ores must be coordinated and done with care. The products shipped must also be weighed and sampled and their metallic contents determined. By comparing the amount of the metal entering into the plant with that shipped, the recovery and the loss in metal are determined. The recovery of metal varies with different ores, different metals, and different processes used. In no case can 100 per cent of metal be recovered, as no process has yet been devised by which all the metal in an ore can be recovered. If such figures are obtained, the ore has probably been undersampled or underweighed, or excessive moisture results have been accepted. The statement is sometimes made, for instance, that a certain plant smelting copper ores has recovered 101 per cent of the gold contained in its ore. In this instance the gold is a minor product, and the seeming discrepancy is explained by the fact that although certain ores in which the value of the gold content was less than 20 cents per ton were not assayed for gold, a large proportion of the gold was recovered thereby indicating a greater recovery of gold than, according to assay figures, actually entered the plant in the ores.

At the present time most smelting plants charge up against receipts in the metal account the total metal received, as determined by assay of gold and silver and by wet analysis of copper, lead, etc. It is customary to set certain limits on the amount of metal in an ore that will be paid for. Thus, if there is less than 0.03 ounce of gold, 0.5 to 1 ounce of silver, 5 per cent of lead, or 1 per cent of copper in an ore, these metals are not paid for. At the same time, however, they are charged against the metal account. The difference between the amount of metal in ores received by a plant and that shipped in the intermediate or the finished product is the loss of metal. Sometimes there is a slight gain in metal recovered over that charged. This is often the case in the gold and occasionally in the silver recovered. As the recovery on these metals is more nearly perfect than that for lead and copper, and as small amounts not recorded are recovered, this gain may easily be understood.

Losses in smelting vary greatly, and, in general, as determined by the author, are within the following limits: Lead smelting—lead, 5 to 20 per cent of the contents of the ore; copper, 1.5 to 4 pounds per ton of charge smelted; silver, from a loss of 1.5 per cent to a gain of 1.75 per cent of the silver content of the ores; gold, a gain of 0.3 to 4.5 per cent of the contents of the ores; copper smelting—copper, 3 to 11 pounds per ton of ore smelted; silver, 0.5 to 10 per cent of the contents of the ore; gold, from a loss of 1.5 to a gain of 4 per cent of the contents of the ore.

SMELTER AND MILL RATES AND SCHEDULES.

"FLAT" CHARGES FOR MILLING.

Milling rates, or charges for the milling of ore by such processes as amalgamation and cyanidation, are made on a comparatively simple basis. Usually a "flat" charge is made, which varies with the value of the ore. Gold is paid for, usually, at the rate of $20 an ounce, and silver at the New York quotation on the day of settlement. The percentages of recovery in milling are often, though not always, lower than those in smelting, and it not uncommonly happens that less than 90 per cent of the gold in an ore is paid for; if the amount of silver in an ore is small, it may not be paid for at all. Sometimes the whole of the assay value in gold is paid for and the loss provided for by including it in the flat charge.

The recovery of silver by milling, except from certain ores, like those of Tonopah, Nev., is almost invariably lower than that of gold, and the percentage of silver paid for varies from 50 to 90, according to the character of the ore. Milling rates and schedules have not been standardized, as have smelting schedules and rates. As an example the table following is presented. It gives milling rates on gold ores in the Cripple Creek district.

Milling rates on Cripple Creek ores, including freight charge.

[Full assay value in gold paid for at $20 per ounce.]

Value of ore per ton.	Charge per ton for treatment.	Value of ore per ton.	Charge per ton for treatment.
Up to $10	$4.00	$25 to $30	$6.50
$10 to $15	5.00	$30 to $40	7.00
$15 to $20	6.00	Over $40	8.00
$20 to $25	6.25		

RELATION OF PRACTICE TO CHARGES IN CUSTOM SMELTING.

Smelter rates and schedules are much more complex. In fact, the main principles on which they are based are not fully understood by some persons who regularly buy and sell ores. In custom smelting—that is, in smelting lots of ore purchased from widely different sources—it is the aim, as far as possible, to put into the furnace a mixture that will be "self-fluxing"—that is, one that will smelt down uniformly without addition of barren flux, producing, if possible, a slag of proper composition and giving a good furnace tonnage. The slag or molten fluid waste product in lead and copper smelting is essentially a silicate of lime and iron oxide containing some alumina and also comparatively smaller proportions of such constituents as zinc oxide, magnesia, and barium oxide as silicates. In lead smelting the relative proportions of the main constituents—silica, lime, and iron oxide—that may be present are rather sharply defined within certain limits. In copper smelting a greater latitude in the relative proportions of these constituents is permissible. Nevertheless the composition of the slag, and hence the composition of the "charge" fed to the furnace, must not vary except within comparatively narrow limits. An ore by itself seldom smelts down and yields the proper slag, and usually other ores of different composition or barren flux, such as ore high in iron, limestone, or highly siliceous material, must be added in order to carry on the smelting operation.

As it costs a definite sum to smelt a ton of furnace charge of proper composition, it is evident that the greater the proportion of barren flux in this ton of furnace charge the higher will be the cost that must be borne by the ore or valuable substances. If, however, barren flux, such as limestone or iron ore, can be replaced by ores containing lime and iron, the smelting cost per ton of furnace charge will be distributed amongst a greater proportion of material able to stand such cost. Smelting plants centrally located as regards railroad lines and having a varied ore supply are enabled to make furnace mixtures from their various ores, so that barren flux is largely excluded.

BASIC SMELTING CHARGE.

On the basis that it will cost for capital invested, labor, fuel, repairs, depreciation, etc., a certain sum per ton of furnace charge a basic smelting charge per ton may be made to cover this expense. This basic smelting charge is the criterion upon which smelting rates are based. If an ore is shipped to the smelter that contains more silica than is permissible in the ideal furnace charge as outlined, a penalty is imposed based on the proportion of silica in excess of that

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which the furnace charge should contain. The reason for the penalty is that the excess silica must be provided for by the addition of iron or lime flux, and the extra charge imposed is the cost of this flux. Hence if an ore be received that contains iron in excess of that called for by the ideal furnace charge, this will be available for fluxing the excess silica contained in the first ore, and the penalty exacted from the shipper of the siliceous ore may be returned as bonus for the excess iron in the ferruginous ore. The effect is to increase the smelting charge on siliceous ore and decrease the charge on ferruginous ore and still maintain the smelting charge per ton of furnace mixture constant. By these means the mining of ferruginous ore is stimulated and the mining of siliceous ore is not unduly discouraged. This basis of imposing smelting charges is termed the "neutral schedule" from the fact that iron "neutralizes" or fluxes the silica in the charge.

EFFECT OF THE NEUTRAL SCHEDULE.

Theoretically the smelter obtains no advantage from this system, but in practice it sometimes amounts to an incidental profit. The bonus paid on a unit, or 1 per cent per ton, of excess iron is usually about 5 to 10 cents, whereas the penalty on excess silica is usually 10 to 15 cents. It is assumed that in the ideal smelting mixture one part silica fluxes one part iron,[a] so that in order to obtain excess silica or excess iron the proportion of either of these substances present in a smaller quantity is subtracted from the proportion of the other, present in a larger quantity, the difference being the excess. If the excess is iron, it is multiplied by the bonus per unit and the product is subtracted from the smelting charge. If the excess is silica, it is multiplied by the penalty per unit and the product is added to the smelting charge. It is sometimes customary to multiply the contents in silica and iron by the respective penalty or bonus, subtract the lesser product from the greater and add or subtract the result to or from the smelting charge. As the penalty for silica is usually greater than the bonus for iron, this method favors siliceous ores more than the system of calculating excess first described.

CHARGES FOR SILICEOUS ORES.

In most districts iron is much scarcer than silica, so that there is usually more siliceous than ferruginous ore available. However, it sometimes happens that this order is reversed and that ferruginous ores are more common than siliceous ores, in which case the penalty may be imposed on the iron and the bonus given to the silica. This variation is, however, not common and when siliceous ores are in great demand it is customary to make a low "flat" or fixed charge for smelting siliceous ores. The "flat schedule" is based on the assumption that it costs a certain sum to smelt such ores. To this sum is added an amount for profit, etc., to make the smelting charge. The flat schedule pays no attention to the composition of the ore, as does the neutral schedule. However, in most instances the flat schedule is on a sliding basis, dependent upon the value of the ore; that is, the smelting charge either increases or decreases with the value or metal content of the ore. The accompanying table shows the increase in smelting charge with increase in value for siliceous gold-copper ore in the Colorado district.

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[a] This is really one part iron or lime and is true for copper smelting. For lead smelting one part silica requires two parts iron plus lime, approximately.

Schedule of smelting rates on siliceous ores in the Colorado district.

Value of ore per ton.	Charge for treatment per ton.	Value of ore per ton.	Charge for treatment per ton.
$14 and less	$5.00	$35 to $40	$8.00
$14 to $20	6.00	$40 to $45	8.50
$20 to $25	6.50	$45 to $50	9.00
$25 to $30	7.00	$50 and more	10.00
$30 to $35	7.50		

REASON FOR INCREASING SMELTING CHARGES ON HIGH-GRADE ORES.

The justification for increased smelting charges on high-grade ores is the fact that the smelting charge on low-value ores is very nearly the actual cost, and perhaps a little below it, and high-grade ore can bear higher charges. If the relative tonnage of each class be considered, the average smelting charge for all high-grade ores will be greater than that for the low-grade ores.

Were no sliding scale adopted, and all ores, irrespective of value, charged the average rate, that rate would be so high as to make the production of low-grade ores unprofitable. Hence, a sliding scale with low rates on low-grade ores stimulates the mining of that class of ore and increases production. If the value of an ore is largely in gold, with some copper, an increase in value little affects the composition of the ore as regards its smelting properties. When, however, the increase in value is due to a proportionately larger metal content—as in lead and copper ores, for instance—the large metal content means less gangue to be fluxed in the furnace. Ores of high metal content—as, for instance, 40 to 50 per cent lead—are cheaper to smelt than ores containing less metal and more gangue. Hence, smelting rates on lead and copper ores decrease progressively with increasing metal content as the table following illustrates.

Smelting rates on lead ores.

Proportion of lead.	Smelting charge per ton.	Proportion of lead.	Smelting charge per ton.
5 to 10 per cent	$10.00	25 to 30 per cent	$4.50
10 to 15 per cent	8.50	30 to 35 per cent	3.50
15 to 20 per cent	7.00	35 to 40 per cent	2.00
20 to 25 per cent	5.50	Over 40 per cent	1.00

METHODS OF PAYING FOR METAL CONTENTS OF ORES.

As already stated, no metallurgical process recovers all the metal in the ore, and hence payment for all the metal can not be expected. Therefore, a deduction is made from the metal content to allow for loss in treatment. Formerly, both copper and lead were determined in ores by the fire assay, or "dry" assay, just as gold and silver is now. Although the assay for gold and silver is perhaps more accurate than any wet analysis, this method for lead and copper is unreliable usually giving lower results than wet analysis.

MANNER OF DETERMINING PROPORTION OF LEAD IN ORES OR CONCENTRATES.

Lead may be determined in two ways, as follows: (1) By wet analysis, which gives the so-called "wet lead"—that is, the actual amount of lead in the ore—and (2) by fire assay, in which the lead content is determined by fusion in a crucible. The fire assay for lead is an old method, in use many years, and is supposed to give results equivalent to the actual yield by smelting. Fire assaying may be considered smelting on a small scale. Therefore the smelter buys lead in ores on the basis of the fire assay, as the assay results represent, in theory, the lead that he may expect to recover.

COMPARISON OF FIRE ASSAY WITH WET ANALYSIS.

For ores that contain no appreciable proportions of easily reducible metals, like copper, antimony, and bismuth, or like zinc and arsenic, aside from the lead, the fire assay gives results that are lower than those obtained by the wet analysis. The difference is usually about 0.5 to 0.9 per cent; that is, an ore showing 35 per cent lead by wet analysis gives 34.1 to 34.5 per cent by fire assay, or 700 pounds per ton by wet analysis and 682 to 690 pounds by fire assay. On ores containing appreciable proportions of the metals mentioned above, the fire assay often gives higher results than the wet analysis, as some of the metals are reduced with the lead, but these fire-assay results are of course incorrect. It follows, therefore, that in buying "pure ores," or those not containing easily reducible metals other than lead, the smelter wants to buy on the basis of the fire assay, but when buying "impure ores," or those containing other easily reducible metals, he wishes to buy on the basis of the wet analysis, with a deduction to cover the loss in smelting. On the other hand, the position of the miner is reversed. He desires to sell "pure ores" on the basis of the wet analysis and "impure ores" on the basis of the fire assay.

ADJUSTMENT OF DIFFERENCES BETWEEN THE TWO SYSTEMS.

In order to adjust the difficulties named the following practice has been adopted: For pure lead ores, such as are produced in the Coeur d'Alene district, Idaho, the fire assay is still used to determine the amount of lead, although both mining and smelting companies check the results by wet analysis. In other instances, as in Utah, it is customary to make a fire assay and then determine the lead in the fire-assay button by wet analysis and call the result the amount of lead in the ore. In still other instances a wet analysis is made for lead, and a deduction of 1, 1.3, or 1.5 per cent is made from the result to give the so-called "dry assay" the equivalent of the fire assay. For example, if an ore gives a content of 20 per cent lead by wet analysis, the dry content will be 19 to 18.7 or 18.5 per cent, dependent on the deduction agreed upon. The matter summed up is that an effort is made to determine the percentage of lead in the ore that is recoverable by the smelting operation.

SMELTING LOSSES IN LEAD SMELTING.

The question arises whether the results obtained by fire assay correspond to the yield in smelting. The losses in lead smelting, exclusive of those connected with refining, may be stated as ranging from about 4.5 to 17 per cent of the lead smelted, as determined by wet analysis. Such losses include the loss incurred in roasting a fair percentage (35 per cent) of the furnace charge. The low figure applies to the smelting of a furnace charge high in lead, that is, a charge, considered as a whole, that contains about 30 to 35 per cent of lead, whereas the high figure applies to furnace charges low in lead, say somewhat less than 10 per cent, or to charges that contain a large percentage of roasted material. The loss in normal smelting, or with 10 to 15 per cent of lead on the charge, is 8 to 11 per cent. Therefore, an ore containing 35 per cent, or 700 pounds, of lead per ton, or 682 pounds by fire assay, will yield in the normal furnace charge 89 per cent of its contents, or 623 pounds, a loss of 77 pounds, or 59 pounds more than the fire assay indicates. In the same way a deduction of 1.5 per cent from the lead content of this grade of ore does not cover the smelting loss. On the other hand, if an ore contains 10 per cent lead by wet analysis, or 200 pounds per ton, and the smelter pays for 10 – 1.5 per cent, or 8.5 per cent, or 170 pounds per ton, and he again recovers 89 per cent, or 178 pounds, it is obvious that his deduction more than covers his smelting loss.

It is therefore generally true that the fire-assay basis or its equivalent, the dry-analysis basis (wet analysis less 1.50), does not cover smelting losses for medium or high-grade ores, but somewhat more than covers smelting losses for low-grade ores, provided a furnace charge containing not less than 12 per cent lead can be made up from the ores.

DEDUCTION TO COVER SMELTING LOSS.

In order to safeguard himself, the smelter makes an additional deduction to cover loss in smelting. The procedure in Utah is as follows: The smelter pays for 90 per cent of the lead content, either determined by the fire assay or put on the dry-analysis basis; that is, lead determined by wet analysis less 1.5 per cent. When this additional deduction is made the total deduction more than covers any loss, as per the following example: In an ore containing 35 per cent or 700 pounds of lead by wet analysis, or 682 pounds by fire assay, payment will be made for 90 per cent of 682 pounds, or 613.81 pounds. The loss in smelting this ore under the conditions already described will be 77 pounds, or 9.2 pounds less than the deduction made. Again, as the grade of the ore decreases the deductions made will become considerably greater than the actual losses.

In Colorado no special additional deduction is made, but its equivalent is obtained by paying less for the lead.

MANNER OF DETERMINING THE PROPORTION OF COPPER PAID FOR IN ORES AND CONCENTRATES.

Copper content is determined by wet analysis, either electrolytically or else volumetrically by the iodide or cyanide method. In the Michigan district the fire assay is still used somewhat for metallic copper concentrate or "mineral." As with lead the smelter desires to obtain a figure representing the "yield," as this theoretically corresponds to what he recovers in smelting and is all that he can be expected to pay for. Hence the copper paid for is the "dry copper," that is, the actual amount of copper as determined by the wet assay less a standard deduction for changing to dry basis. This deduction is usually either 1, 1.33, or 1.5 per cent, but occasionally may be as low as 0.75 per cent. Naturally, therefore, when the copper content of an ore is less than 1.5 or 1 per cent, it is not paid for. When an ore contract specifies that the copper content on the basis of a dry analysis is equivalent to "wet less 1.5 per cent," it means that if an ore contains actually 12.5 per cent, or 250 pounds per ton, payment will be made for only 220 pounds, the difference, or 30 pounds, representing loss in smelting.

Usually the placing of the copper content on the dry basis fully covers any smelting losses sustained. According to the grade of the ores smelted, copper losses vary from 5 to 15 per cent, the higher figure applying to ores of lower grade.

MANNER OF DETERMINING THE PERCENTAGE OF GOLD AND SILVER PAID FOR IN ORES AND CONCENTRATES.

The deduction for loss in extracting gold and silver is made somewhat differently. Often the deduction for smelting loss is 5 per cent of the gold content and 5 to 10 per cent of the silver content. Thus a contract may read, "Gold will be paid for at 95 per cent of the assay at $20 per ounce. Silver will be paid for at 95 per cent of the assay at New York quotations." In other instances, in place of making a percentage deduction from the assay to cover loss, the price paid per ounce will be decreased to $19 per ounce for gold. Gold in an ore is usually not paid for if less than 0.03 ounce per ton is present, and silver is not paid for if less than 1 ounce per ton is present. This is due to the fact that in a smelting mixture giving a certain type of slag the slag will contain a fixed amount of metal as loss. In smelting low-grade ores the loss is much greater than in smelting high-grade ores, and hence small amounts of gold and silver in ores are considered as largely lost in the slag.

DETERMINATION OF COST OF FREIGHT AND OF REFINING METAL IN CRUDE PRODUCT.

So far the charges for smelting the ore to a crude product and the deductions for the loss of metal during smelting have been considered. There still remains to be added to the total smelting charge the cost of freight to the refining center and of refining the metal in the crude product, so that it may be placed on the market. This charge is imposed by paying for the metal content a lesser price per pound or unit than the quotation for refined metal. Thus copper in ore may be paid for at the New York quotation on electrolytic copper, on the date of assay, less 3 cents per pound, this 3 cents covering the refining, freight, and selling charge. Sometimes copper is paid for on the unit basis, for instance, $2.80 per unit of 20 pounds. With refined copper at 17 cents, this is equivalent to a deduction of 3 cents per pound.

This method, however, is not common for copper ores because it leaves out of consideration the fluctuations in copper prices and places a fixed value on the copper content of the ore during the terms of the contract. Lead in ore is more frequently bought on the unit

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basis, the price per unit varying with the sales price of the metal in New York. The price paid per unit of lead is always less than the value of 20 pounds of lead at prevailing lead prices. Thus lead may be paid for at 50 cents per unit when the price of lead in the market is 4 cents per pound. This rate means a deduction of 30 cents per unit or 1.5 cents per pound to cover refining and freight charges. When copper and lead in ores are bought on a unit basis, payment is usually made on a sliding scale, higher prices being paid per unit on ores that are high in metallic content.

PAYMENT FOR LEAD IN ORES.

Payment for the amount of lead in ores, after the percentage has been determined by fire assay, or by wet analysis less either 1 or 1.3 or 1.5 per cent, is made according to one of three methods, as follows:

1. By the unit and at quotation, a system used chiefly in Colorado.
2. For 90 per cent of the lead content at the sales price, with a deduction per pound, a system used chiefly in Utah.
3. For 90 per cent of the lead content at 90 or 95 per cent of the sales price, a system used to some extent for Idaho ores.

UNIT-AND-QUOTATION SYSTEM.

Following are examples of payment by the unit-and-quotation system. The smelter pays for wet lead, less 1.5 per cent, as follows:

Lead content of ore, dry basis.	Price per unit.[a]	Lead content of ore, dry basis.	Price per unit.[a]
5 to 10 per cent	$0.35	25 to 30 per cent	$0.49
10 to 15 per cent	.40	30 to 35 per cent	.51
15 to 20 per cent	.45	Over 35 per cent	.51
20 to 25 per cent	.47		

[a] Unit equals 1 per cent, or 20 pounds, per ton.

The price per unit is based on what is called a "quotation" of $4 per 100 pounds of lead. For every rise or fall of 5 cents in the quotation 1 cent is added or deducted from the price per unit. The quotation is not the sales price in New York, but is determined as follows: If the sales price in New York is $4 per 100 pounds, the quotation taken is 90 per cent of this price, or $3.60. If the sales price is more than $4 and not above $4.50, the quotation is obtained by taking $3.60 and adding to it one-half of the excess of the sales price over $4. If the sales price is more than $4.50, the quotation is obtained by taking $3.60 and adding to it half the excess of the sales price between $4 and $4.50 and all of the excess above $4.50.

As a concrete example of payment by the unit-and-quotation system, suppose the sales price in New York is $4.30 per 100 pounds.

The quotation will then be determined as follows: \$3.60 + ½ (\$4.30 − \$4.00) = 15 cents, or \$3.75.

In the case of an ore containing 35 per cent lead, for which, according to the table, 51 cents is paid per unit on the basis of a \$4 quotation, the price will become 51 cents, less as many cents as there are 5-cent units in the difference between \$4 and the new quotation of \$3.75. The difference is 25 cents; therefore a deduction of 5 cents per unit is made from 51 cents, and the actual price per unit paid is 46 cents.

By way of further example, suppose the sales price in New York is \$5 per 100 pounds. The quotation will then be as follows: \$3.60 + ½ (\$4.50 − \$4.00) + (\$5.00 − \$4.50), or \$4.35. For a 35 per cent ore for which 51 cents per unit is paid on a quotation of \$4, the price per unit will become 51 cents + ⅕ (\$4.35 − \$4.00), or 58 cents.

Question.—If a miner has a ton of lead ore that contains 36.5 per cent of lead by wet analysis, and the sales price of lead in New York is \$4.30 per 100 pounds, what would be the value of this lead in New York, and what does he receive for it from the smelter?

Answer.—The ore contains 730 pounds of lead, which, at \$4.30 per 100 pounds, amounts to \$31.39. The miner is paid for 35 per cent lead at 46 cents per unit, or \$2.30 per 100 pounds, a total of \$16.10. The difference is \$15.29. Of course the miner is in no sense entitled to the full value of his lead, for certain losses and charges must be deducted; however, it is not just to make too great a deduction.

PAYMENT ON BASIS OF 90 PER CENT OF LEAD CONTENT AT SALES PRICE WITH A DEDUCTION PER POUND.

Under the method of payment on the basis of 90 per cent of the lead content at the sales price, with a deduction per pound, the lead content is determined by the fire assay, or by the wet method less the deduction of 1 or 1.3 or 1.5 per cent. Ninety per cent of the lead thus determined is paid for if more than 5 per cent lead be present; if the proportion be less than 5 per cent, it is not paid for. The lead is paid for at the New York sales price, less a deduction of 1.5 cents per pound, if the lead content of the ore is less than 25 per cent; a deduction of 1.25 cents per pound is made if the lead content is more than 25 per cent.

Question.—If a miner has a ton of lead ore that contains 36.5 per cent of lead by wet analysis and the sales price of lead in New York is \$4.30 per 100 pounds, what would be the New York value of this lead to the miner and what does he receive for it from the smelter?

Answer.—The ore contains 730 pounds of lead, which, at \$4.30 per 100 pounds, amounts to \$31.39. He is paid for 90 per cent of 35 per cent (36.5 per cent less 1.5 per cent) of lead, or 630 pounds, at the rate of 4.3 cents, less 1.25 cents, or 3.05 cents per pound, which amounts to \$19.21. The difference is \$12.18.

PAYMENT ON BASIS OF 90 PER CENT OF LEAD CONTENT AT 90 OR 95 PER CENT OF SALES PRICE.

Under the method of payment for 90 per cent of the lead content at 90 or 95 per cent of the sales price, the lead content is determined by the fire assay or by the wet method less the deduction of 1 or 1.3 or 1.5 per cent. Ninety per cent of the lead thus determined is paid for at 90 or 95 per cent of the sales price in New York as may be agreed upon. Lead in an ore, if less than 5 per cent, is not paid for.

Question.—If a miner has a ton of lead ore that contains 36.5 per cent of lead by wet analysis, and the sales price of lead in New York is $4.30 per 100 pounds, what would be the value of this lead in New York and what does he receive for it from the smelter?

Answer.—The ore contains 730 pounds of lead, which, at $4.30 per 100 pounds, amounts to $31.39. He is paid for 90 per cent of 35 per cent (36.5 per cent less 1.5 per cent) of lead, or 630 pounds, at 90 per cent of $4.30, or at the rate of $3.87 per 100 pounds. This amounts to $24.38. The difference is $7.01.

COMPARISON OF RATES UNDER THE THREE METHODS.

A comparison of the rates under the three methods for the three examples presented is given below:

Comparative rates paid for lead in ore under three methods of payment.

Method of payment.	Quantity of ore.	Lead content.	Gross ore value.	Paid to miner.	Value to smelter.
	Tons.	*Per cent.*			
By the unit, and at quotation	1	36.5	$31.39	$16.10	$15.29
On basis of 90 per cent of lead content at sales price, with deduction per pound	1	36.5	31.39	19.21	12.18
On basis of 90 per cent of lead content, at 90 or 95 per cent of sales price	1	36.5	31.39	24.38	7.01

Evidently the first system gives the least return on the lead. In this connection the reader should note, however, that the ore schedule or contract as a whole must be considered. For instance, under the first system, treatment charges are much lower than under the third system, so that the net outcome to the miner may be about the same on the same kind of ore under any of the systems.

ABSORPTION OF EXCESS VALUE BY THE SMELTING COMPANY.

In certain instances the smelter absorbs part of the rise in price of lead when the sales price goes above a certain figure. Thus, if the sales price in New York is $4 or less per 100 pounds, the smelter pays at the rate of 90 per cent of the sales price. But if the sales price rises to a figure between $4 and $4.50, the smelter will not pay at the rate of 90 per cent of the sales price, but will pay for only 90 per cent of $4 plus one-half of the excess of the sales price over $4. If the sales price is above $4.50, it will pay for 90 per cent of $4 plus one-half of the excess between $4 and $4.50 and all of the excess above $4.50. As an example, if the sales price in New York is $4.80 per 100 pounds, the miner on the basis of 90 per cent of the sales price should receive $4.32 per 100 pounds. Actually he receives on the modified basis 90 per cent of $4, or $3.60, plus ½ ($4.50 – $4) plus ($4.80 – $4.50), or $4.15 per 100 pounds. The difference of 17 cents per 100 pounds is absorbed by the smelter.

A feature of most schedules is that they do not provide for payment for a lead content of less than 5 per cent. In some instances a lead content of less than 5 per cent is paid for at the same rate as the bonus is granted on iron, namely, at 15 cents per unit, as against the rate of about 40 cents per unit usually paid for lead when present in low percentage. Another feature is that the price per unit paid for the lead in ores of low lead content is less than that for ores of high lead content. In the same way under the second system the deduction per pound is greater for ores of low lead content than for ores of high lead content. This difference is perhaps justifiable from the smelters' standpoint in that the losses are comparatively greater in smelting low-grade ores than in smelting high-grade ores.

PAYMENT FOR COPPER IN ORES.

Payment for copper in ores, the percentage present being determined by wet analysis, less 1, 1.3, or 1.5 per cent as the case may be, is made on the basis of the New York price of refined copper less a deduction to cover the cost of refining and freight of the metal to the market. The quotations in New York are made on three brands of copper, as follows: (*a*) Electrolytic copper in the form of ingots or wire bars; (*b*) electrolytic copper in the form of cathodes—that is, the electrolytically deposited copper in its original form previous to melting, and (*c*) casting copper, or copper not electrolytically refined and only reasonably pure. Cathodes are usually quoted at about 0.1 cent less, and casting copper at 0.2 cent less than wire bars. The amount of the deduction from the market price is given in the accompanying table.

Smelters' deductions from market prices for copper.

Kind of ore.	Copper content of ore.[a]	Deduction per pound.
	Per cent.	
Lead ore containing copper	1.5 to 5	6 cents off casting-copper quotation.
	5 to 10	5 cents off casting-copper quotation.
	More than 10	4 cents off casting-copper quotation.
Copper ores	1.5 to 5	5 cents off electrolytic-copper quotation.
	5 to 10	4½ cents off electrolytic-copper quotation.
	10 to 20	4 cents off electrolytic-copper quotation.
	20 to 30	3½ cents off electrolytic-copper quotation.
	More than 30	3 cents off electrolytic-copper quotation.

[a] Dry copper content represents content as determined by wet analysis less 1½ per cent.

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It will be noted that the deduction on lead ores containing copper is greater than on "straight" copper ores, the reasons being as follows:

When copper is present in an ore that goes to make part of a mixture smelted in the lead blast furnace, the aim of the metallurgist is to recover this copper in the form of a matte. The liquid products that flow from the furnace are (1) lead, which contains alloyed with it gold and silver and small amounts of certain impurities like bismuth, arsenic, antimony, small amounts of sulphur, and some copper; (2) matte, a sulphide of iron, copper, and lead containing some silver and a little gold; (3) slag, which is the molten refuse of the furnace, composed of the gangue, or worthless material of the ore. This slag always carries away with it a certain proportion of the valuable metals—lead, copper, gold, and silver. These three products have decidedly different specific gravities, so that they can be readily separated, the lead, or heaviest, being separated in the furnace, whereas the slag, or lightest, is separated from the matte in a settling chamber directly in front of the furnace. The slag goes to waste and the matte is saved.

REASON FOR FORMATION OF MATTE.

The formation of matte is due to the presence of sulphur in the furnace charge, and the amount produced is in direct proportion to the amount of sulphur present. If no sulphur were present, no matte would be formed, and any copper in the furnace charge would enter the lead. This result would be undesirable, because the refining of lead containing considerable copper is costly and wasteful. If too much sulphur be present too much matte will be formed, in turn taking up a large quantity of lead, and making the refining of this product costly and wasteful. The real object, therefore, in forming matte is to throw the greater part of the copper present in the furnace charge into a separate product from which it can be more easily recovered.

The matte produced in the lead furnace is different from the matte produced in copper smelting in that it contains some lead, as well as copper. Its treatment for the recovery of the metals in it is consequently more costly than that of a copper matte, and this fact is reflected in the deductions made from the price of copper in lead ores as against those made from the price of copper in copper ores. Copper in lead ores is usually paid for at market price less 4 to 5 cents per pound, whereas copper in copper ores is paid for at market price less 2 to 3 cents per pound.

PENALTIES.

Penalties are extra charges added to the smelting charge on account of the presence in the ore of certain undesirable substances. The matter of penalty for excess silica has been discussed rather fully. The reason for the payment of a bonus for iron has been mentioned. Substances, the presence of which is commonly penalized, are zinc, sulphur (in lead smelting), arsenic (sometimes loosely called speiss), and antimony.

PENALTY FOR ZINC.

The zinc in the ore is not recovered in the process of lead or copper smelting but passes partly to the slag and partly into the fume and flue dust. The slag may contain as much as 8 or 10 per cent of zinc without much detriment, but when the proportion is greater, the slag becomes viscid, decreasing the furnace capacity and increasing slag losses. In the fume, zinc causes trouble by incrustations in the furnace and by increasing losses by volatilization. Hence a limit of 10 per cent zinc is usually placed on ores, and every unit (20 pounds) per ton above this amount is penalized at the rate of 30 to 50 cents, the penalty charge thus obtained being added to the smelting charge. This penalty is so heavy that in dressing ores there is a decided incentive to separate the zinc minerals into a distinct product whenever possible, thus avoiding the penalty on zinc in the lead and copper product, and at the same time obtaining a salable zinc product that may be sold to the zinc smelter.

PENALTY FOR SULPHUR.

A sulphur content greater than 3 per cent is penalized in lead smelting. It is customary to impose a penalty of 20 cents on each unit of sulphur in excess of 3. In lead blast-furnace smelting, only a small percentage of sulphur is permissible in the charge, and ores high in sulphur must first be roasted. The roasting entails considerable expense, which is met by the imposition of a penalty on the sulphur content, this penalty being added to the smelting charge. In copper smelting, sulphur is desirable rather than otherwise and is not penalized.

PENALTY FOR ARSENIC.

Arsenic is commonly penalized in lead smelting and, occasionally, in copper smelting.

Penalty is usually imposed on an arsenic content greater than 1 unit. The presence of arsenic in the lead blast-furnace charge causes the formation of an artificial arsenide of lead, iron, and copper, known as speiss, a most undesirable by-product and costly to treat for the recovery of the contained metals. Its undesirable qualities usually become apparent in the refinery. If arsenic be present in the furnace charge in small amounts, it will pass into the lead bullion, making this difficult to refine.

PENALTY FOR ANTIMONY.

Antimony causes difficulties somewhat similar to those occasioned by arsenic, but is recovered in the refinery in the form of antimonial lead, which is a salable product, so that a penalty is rarely imposed on antimony in lead-smelting operations.

VARIATION OF PENALTIES.

The limits set for the occurrence of undesirable constituents vary much in schedules and contracts. Thus it is by no means standard that 3 per cent represents the upper limit for sulphur content in lead ores, so as to be free from penalty. Occasionally penalty is imposed on a sulphur content greater than 1 per cent, and again it may not be imposed until 6 per cent is reached. The same remarks apply to zinc and other substances subject to penalty. Neither are the prices charged per unit uniform or standard. Limits and prices are usually subject to agreement between the ore seller and the smelter.

MARGINS.

It is apparent from the foregoing discussion that the deductions made for the smelter from the gross value of the ore is much more than the smelting charge alone, for it consists of that charge, plus the deductions resulting from the lesser price paid for the metals, the lesser amount of metal paid for, and the charge for penalties. The smelter also deducts the freight charge on the ore and makes settlement for this with the railroad company.

In discussions of the smelter business, the term margin is often used; it may be briefly defined as the difference between the actual value of the ore to the smelter and the amount paid the shipper of the ore. What is paid the shipper of the ore is the difference between certain credits and debits, the credits consisting of the sum due on metals at the agreed amounts and prices as per the contract, and the bonus allowance on iron or lime; the debits consist of the freight and treatment charges and the penalties imposed. The difference is the net amount paid the shipper.

The gross value of the ore to the smelting plant, if this be of the ordinary type, not refining its own product, is the total metal content (100 per cent) at a certain price per metal which is arrived at by taking the market quotation for the metal and subtracting from this a sum to cover the refining charge and the freight of the metal to the market. For example, if copper is quoted at 16.3 cents per

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pound at New York, a Western smelting plant will figure copper to be worth 14.7 cents per pound at the plant, the difference, 1.6 cents, being allowed to cover refining and freight to market. In the same way, with lead quoted at 4.35 cents per pound at New York, a certain smelting plant will figure lead to be worth 3.34 cents to itself at the plant, the difference of 1.01 cents covering refining and freight. Similar allowance is made for the cost of recovering and refining silver and gold.

The gross value of the ore to the smelting plant, determined as outlined above, less the net amount paid the shipper, is the margin on the ore to the smelting plant. This margin is the amount that the smelter has to cover his cost and profit and loss. As he has charged himself with 100 per cent recovery of the metals, the loss of metal in smelting will appear as a charge against the margin. In calculating the final outcome to the smelting plant it is again desirable to consider debits and credits, the margin plus the value of the iron and lime contents being the credit, whereas the metal loss placed at the smelter's value for the metals, the charges for the silica and sulphur contents of the ore, the base cost of smelting, the cost of converting copper, and the interest charge for holding the metal stock, are the debits. The difference between debits and credits is the profit or loss. The refining company will conduct its accounts in a similar manner.

RÉSUMÉ.

It is evident from the foregoing that smelting rates and schedules are of a complex nature, although the principles on which they are based are reasonably simple. It is frequently stated that these rates and charges are made willfully complex by the buyer, in order to obscure the amount of the deductions made. This view may perhaps have been correct in some instances, but the main reason for the complexity of present rates and schedules is to be found in the fact that the details have been increased from time to time as the smelting industry grew, new processes were invented, and new types of ores were found. It certainly seems desirable that the rates and schedules should be simplified in order that they may be more comprehensible to shippers of ores, particularly the small shipper who often is not familiar with the intricacies of the business and hence is not in a position to know whether justice is done him.

There is little question but that the principles upon which the rates and schedules are founded are just enough. However, individual deductions and charges for smelting might not be so reasonable. At first sight it would seem that when lead is worth 4.7 cents per pound, a deduction of over 60 per cent of this value to cover smelting, refining, and freight is too much. Determination can not be made superficially, but there is no question but that, per ton of

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metal recovered, the smelting of low-grade lead or copper ore is much more costly than that of high-grade ore.

Another point of contention relates to the deduction for silica and the bonus for iron when ore is purchased on the neutral schedule. Frequently the penalty for excess silica is 12 cents and the bonus for iron is 10 cents. It is claimed that the penalty and the bonus should equal each other. This claim is perhaps reasonable in copper smelting, in which the unit of silica is about equivalent to a unit of iron, but in lead smelting two units of iron plus lime are needed to be equivalent to one unit of silica, so that it seems fair to make the penalty on silica higher than the bonus for iron. However, in many contracts at the present time the bonus and penalty figures are equal. It is customary for a shipper who controls a considerable ore supply to enter into contract with the smelting company for the treatment of his ores. In instances of this kind, which are frequent, much better rates and schedules are often obtained than are specified in the so-called open schedules, which are published for the shipper of small isolated lots. Rates also vary, the variation being dependent on the demand for certain kinds of ore. Thus, at times the siliceous or "dry" ores are scarce and again ferruginous ores are scarce, so that rates vary with the supply.

COMPLETE SCHEDULES ON COPPER-LEAD, GOLD AND SILVER ORES.

Below are complete "open schedules" for copper-lead, gold, and silver ores in force in the Western sections of the United States.

(A) Schedule on Lead Ores and Lead-Copper Ores Containing Gold and Silver.

(1) NEUTRAL SCHEDULE 1. USED CHIEFLY IN COLORADO.

Gold, $19.50 per ounce if 0.05 ounce or over per ton.

Silver, 95 per cent of contents at New York quotation, date of assay.

Lead (dry), as below, prices based on "quotation" of $4.

Copper, for dry copper (1.5 per cents off wet), and 6 cents off per pound on Western Union quotation for casting copper.

Zinc, 10 per cent allowed; 50 cents penalty per unit for zinc in excess of 10 per cent.

Silica penalty, 10 cents per unit; iron bonus, 10 cents per unit.

Neutral schedule on lead in lead ores and lead-copper ores.

Lead content.	Value per unit.	Smelting charge per ton.[a]	Lead content.	Value per unit.	Smelting charge per ton.[a]
	Cents.			*Cents.*	
5 to 10 per cent	40	$6.00	35 to 40 per cent	52	$1.50
10 to 15 per cent	43	5.00	40 to 45 per cent	52	1.00
15 to 20 per cent	45	4.00	45 to 50 per cent	53	1.00
20 to 25 per cent	47	3.00	50 to 55 per cent	54	1.00
25 to 30 per cent	49	3.00	Over 55 per cent	55	1.00
30 to 35 per cent	51	2.00			

[a] Includes freight charge from a certain district in Colorado, a comparatively short distance from the smelter.

(2) FLAT SCHEDULE.

Payment made on metals as in foregoing schedule.

Flat schedule on lead in lead ores and lead-copper ores.

Lead content.	Value per unit.	Smelting charge per ton.[a]	Lead content.	Value per unit.	Smelting charge per ton.[a]
	Cents.			*Cents.*	
5 to 10 per cent	40	$10.00	35 to 40 per cent	52	$2.00
10 to 15 per cent	43	8.50	40 to 45 per cent	52	1.00
15 to 20 per cent	45	7.00	45 to 50 per cent	53	1.00
20 to 25 per cent	47	5.50	50 to 55 per cent	54	1.00
25 to 30 per cent	49	4.50	Over 55 per cent	55	1.00
30 to 35 per cent	51	3.50			

[a] For concentrate containing more than 30 per cent lead, apply flat or neutral schedule 1; for lead ores, whichever will give a larger return to the shipper, except that a gold content of 0.05 ounce to 2 ounces is at $19 and a content of more than 2 ounces at $19.50.

Neutral schedule 1 to be used when its use will give a larger return to the shipper.

(3) SCHEDULE FOR LEAD CONCENTRATE.

Gold, $19 per ounce when gold content is 0.05 ounce to 2 ounces per ton; when content is more than 2 ounces, $19.50 per ton.

Silver and copper, as in neutral schedule.

Lead, as below, prices based on "quotation" of $4.

Silica, limit 10 per cent; 10 cents penalty for each unit in excess of 10 per cent.

Zinc, limit 10 per cent; 50 cents penalty for each unit in excess of 10 per cent.

Schedule on lead concentrate.

Lead content.	Value per unit.	Smelting charge per ton.	Lead content.	Value. per unit.	Smelting charge per ton.
	Cents.			*Cents.*	
5 to 10 per cent	40	$3.75	20 to 25 per cent	47	$2.25
10 to 15 per cent[a]	43	3.00	25 to 30 per cent	49	2.25
15 to 20 per cent	45	2.50			

[a] More than 10 per cent.

(4) NEUTRAL SCHEDULE 2. USED IN UTAH.

Credits.

Gold, $19.00 per ounce if product contains 0.03 ounce or over per ton.

Silver, 95 per cent of contents, at New York quotations, date of assay.

Copper, as per wet assay, less 1 per cent or unit, at the price for cathode copper quoted in the Engineering and Mining Journal, issue of the week previous to date of receipt, less 5 cents per pound.

Lead.—90 per cent of contents (dry assay) to be paid for at the quotation in the Engineering and Mining Journal, issue of week previous to date of arrival, less 1¼ cents per pound.

Iron.—Paid for at 10 cents per unit.

Charges.

Insoluble.—12 cents penalty per unit.

Zinc.—10 per cent allowed free; excess at 30 cents per unit penalty.

Speiss (arsenic).—10 per cent allowed free; excess at 20 cents per unit.

Sulphur.—25 cents penalty per unit; maximum penalty imposed, $2.50 per ton.

Treatment charge.—$2 per ton, based on an ore carrying 30 per cent lead; for each unit of lead above 30, a credit of 5 cents to be allowed; for each unit of lead below 30, a charge of 8 cents to be made.

B. Schedule on Copper Ores Containing Gold and Silver.

(1) NEUTRAL SCHEDULE.

Credits.

Gold.—$19 per ounce if product contains 0.03 ounce or over per ton.

Silver.—95 per cent of contents at New York quotation, date of assay.

Copper.—As per wet assay, less 1 per cent or unit, at the price for cathode copper quoted in the Engineering and Mining Journal, issue of week previous to date of receipt, less 2½ cents per pound.

Iron.—Paid for at 10 cents per unit.

Charges.

Insoluble.—10 cents penalty per unit.

Zinc.—10 per cent allowed free; excess at 25 cents per unit.

Speiss.—10 per cent allowed free; excess at 25 cents per unit.

Treatment charge.—$3 per ton.

C. Schedule on Siliceous Ores.[a]

Lead and copper not paid for.

Gold and silver paid for as per schedules A4 and B1; treatment charge from $7 to $10 per ton flat, dependent on supply of and demand for this class of ore.

D. Schedule on all Classes of Ores.

Gold.—$19 per ounce if over 0.05 ounce to 2 ounces; $19.50 if over 2 ounces per ton.

Silver.—95 per cent of contents at New York quotation, date of assay, if over 2 ounces per ton.

Copper.—For dry copper (1.5 per cent off wet) 1.5 to 5 per cent, less 6 cents per pound; over 5 per cent to 10 per cent, less 5 cents per pound; over 10 per cent, less 4 cents per pound, from Western Union quotation on casting copper.

Lead.—At 25 cents per unit if over 5 per cent.

Zinc.—Limit, 10 per cent; 50 cents penalty for each unit in excess.

Schedule of charges for treatment of all classes of ore.

Gross value per ton of ore.	Treatment charge per dry ton.	Gross value per ton of ore.	Treatment charge per dry ton.
Under $14	$5.00	$35 to $40	$8.00
$14 to $20	6.00	$40 to $45	8.50
$20 to $25	6.50	$45 to $50	9.00
$25 to $30	7.00	$50 or over	10.00
$30 to $35	7.50		

For lead ores, apply schedule A1 or A2, if either will give a larger return to the shipper than the above schedule.

For "dry" ores—that is, those that do not contain copper or lead above lower limits set—apply $7 treatment charge, with schedule A1, 10 cents penalty, and bonus for silica or iron, respectively, when this figures better for the shipper than schedule A2.

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[a] "Dry ores," or ores that do not contain any copper or lead, or contain those metals in proportions less than 1 per cent copper or 5 per cent lead.

SCHEDULES ON ZINC ORES.

There are no regular schedules in effect for the purchase of zinc ores. Missouri, Wisconsin, Colorado, and Montana are the chief producing States, and the practice of selling zinc ores in the Joplin, Mo., field and the Platteville, Wis., field is considered standard. The metallurgy of zinc differs radically from that of copper or of lead, and it is essential that the ore used be high grade, for low-grade ores can not be used directly at the furnaces. For this reason zinc ores as purchased by the smelter consist largely of concentrate, a high-grade product obtained by either water concentration (including the flotation process) or magnetic concentration from low-grade ores.

A considerable number of smelting companies are active competitors and bidders for the lots of ore offered for sale by the many small producers. Bids are made in the open market, the smelter representative offering a certain price for a given lot of ore. The standard ores are (1) a 60 per cent ore, usually blende, the sulphide of zinc, and (2) a 30 per cent ore, usually calamine, the silicate of zinc. There is a base price for these ores, determined largely by the state of the spelter market; thus in the Joplin district the 1913 base price for the 60 per cent ore ranged from $39.19 to $53.30 per ton, whereas for 30 per cent calamine ore it ranged from $20 to $32 per ton. Naturally the zinc content of the ore varies considerably from the above standard figures, and it is the usual practice to offer a bonus of $1 for every per cent of zinc in excess of the standard figure and to deduct $1 from the base price for every per cent of zinc below the standard figure.

Sometimes a penalty is imposed on lead if it be present in a proportion greater than 0.5 per cent, but this practice is not invariable. A penalty is imposed on iron at the rate of $1 for each per cent if present in excess of 1 per cent. The ores and concentrate, however, are increasing in iron content and recently zinc ore (sphalerite) containing over 6 per cent iron has been bought on the basis of zinc content only, with no special penalty on iron.

The smelter buys the ore outright at the place where it is offered for sale and pays the freight to the smelting plant. The margin of the smelter is, therefore, the difference between the value of the spelter that he obtains from a ton of ore at the base point, St. Louis, and the price he pays for a ton of ore at the mine. This margin usually varies between $8 and $17 and must cover freight on ore, smelting cost, freight on spelter to market, selling cost, and profit. At the recent price of spelter there has been little profit either to miner or smelter, and many smelting companies have been able to operate only by virtue of the fact that they recover sulphuric acid as a by-product from the roasting of the zinc ores or make a special high-grade spelter which brings a premium, or place the spelter on the market in the form of sheets or other manufactured forms.

THE MARKETING OF THE METALS.

COPPER.[a]

The main basing points or markets for copper are New York, London, and Hamburg. There is no duty on either exported or imported copper imposed by the great nations except Russia, so that the copper market is essentially an international one, and prices in the different markets are practically in equilibrium. The selling of copper in the New York market is in the hands of selling agencies, comparatively few in number, which handle nearly all the copper produced. A few of the producers sell their copper direct; for instance, the Quincy, Miami, Mohawk, Wolverine, and some of the smaller Lake companies. Some producers sell their own copper and act also as agents for other producers. Thus the Calumet & Hecla Mining Co. disposes of the copper of those Lake companies in which it holds stock. The Anaconda Copper Mining Co. through its agent, the United Metals Selling Co., sells the Cananea (Mexico), Copper Range, and Highland Boy copper. Phelps, Dodge & Co. sell the copper of the Calumet & Arizona. The American Smelting & Refining Co. sells that of the Utah, Nevada, Ray, Chino, and Tennessee companies.

These concerns sell their outside copper on commission at the rate of about 1 per cent. They dispose of about 80 per cent of the production, and certain other smaller concerns dispose of the remainder. It is the general custom of these selling agencies to sell their copper directly to manufactures of wire, brass, and other copper alloys, copper sheet, and machinery containing copper, so that in the disposal of copper to those who use it the middleman is essentially eliminated. In fact, some of the selling agencies practically refuse to sell to any one except users of copper, in this way largely eliminating any opportunity in this country for speculation in the metal by purchasing large lots and holding them for a rise in price. The price of the copper is controlled by supply and demand. New York becomes the chief market by virtue of the fact that most of the great copper refineries are located in its immediate vicinity, as can be seen from the appended table of the refineries of the United States.

Copper refineries in the United States, 1914.

Name of works.	Situation.	Capacity per annum.
		Pounds.
Nichols Copper Co.	Laurel Hill, N. Y.	400,000,000
Raritan Copper Works	Perth Amboy, N. J.	400,000,000
Baltimore Copper Smelting & Rolling Co.	Canton, Md.	336,000,000
American Smelting & Refining Co.	Perth Amboy, N. J.	216,000,000
United States Metals Refining Co.	Chrome, N. J.	200,000,000
Balbach Smelting & Refining Co.	Newark, N. J.	48,000,000
Anaconda Copper Mining Co.	Great Falls, Mont.	65,000,000
Tacoma Smelting Co.	Tacoma, Wash.	48,000,000
Calumet & Hecla Mining Co.	Calumet, Mich.	55,000,000
Total		1,778,000,000

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[a] Ingalls, W. R., How the metals are sold—copper: Eng. and Min. Jour., vol. 93, May 4, 1912, pp. 887–890.

More than one-half, possibly 55 to 60 per cent in 1913, of the copper production of the United States is consumed in this country, the rest going to Europe.

In London copper is sold from the London Metal Exchange, where transactions are conducted under systematized rules, and an open market is established. This system, of course, gives rise to rather extensive speculation, which is not confined to London. However, the speculation little affects the New York market.

KINDS OF COPPER.

Four principal kinds of copper are marketed, as follows: First, Lake copper, or that produced in the Lake Superior district; second, electrolytic copper, or that produced by the electrolytic refineries, which refine in the main the crude copper from the West; third, pig copper,[a] or copper produced from ores that do not contain sufficient silver to make refining necessary; fourth, casting copper, or that produced largely from old copper scrap, being comparatively impure. There is also another brand, termed cathode copper; this is electrolytic copper before it is melted into ingots or bars. Marketing in this form is uncommon at the present time.

Lake copper, which is the oldest brand of copper in the American market, is uniform in composition and combines purity and good electric conductivity with high toughness. It long commanded a decided premium over other brands and still commands a premium of about ¼ cent per pound over electrolytic copper, New York basis. Electrolytic copper, however, as at present made, is fully as good as Lake copper for almost every purpose and is often of superior electrical conductivity. The premium on Lake copper is perhaps largely due to prejudice. Electrolytic copper constitutes about 80 per cent of the total American copper production, and 70 to 75 per cent of the world's production, and holds the chief place in the copper business. Pig and casting copper are used chiefly in the manufacture of brass, and do not possess the purity that Lake or electrolytic copper has. Some copper companies, such as the Tennessee Copper Co., produce a pig or blister copper of comparatively high purity and with low silver content, less than 2 ounces per ton, so that its electrolytic refining does not pay. Certain smelting companies make a business of purchasing and melting old scrap into ingots of comparatively impure copper. Both these kinds of copper are marketed as casting copper, which is usually sold at 0.1 to 0.2 cent less per pound than electrolytic copper. Cathode copper is generally quoted at 0.05 to 0.11 cent per pound less than electrolytic copper in the form of ingots or cakes.

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[a] Known also as "blister" or "converter" copper. When the copper contains precious metals in sufficient quantity it makes the raw material for the electrolytic refinery. See also Addicks, L., The commercial classification of refined copper: Eng. and Min. Jour., vol. 98, Oct. 31, 1914, p. 776.

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MARKET FORMS OF COPPER.

The copper is placed on the market, first, in the form of pigs similar to the pigs of cast iron, weighing 100 pounds each; second, in cakes or rectangular slabs, of different weights; third, as ingots similar to pigs in shape, but partly divided into two or three sections to facilitate breaking for introduction into the melting crucibles; fourth, ingot bars weighing 60 to 90 pounds, partly divided into three to five parts; fifth, wire bars, which are long bars with square cross section, tapering toward one end and used for making drawn wire. Cakes are used in making rolled copper sheet, and ingots are remelted to make alloys.

BRANDS OF COPPER.

The chief brands of copper in the American market are indicated in the accompanying list:

American Smelting & Refining Co.	PA
American Smelters Securities Co.	BER, BCW (Tacoma)
Anaconda Copper Mining Co.	M A
Arizona Copper Co.	A C C [a]
Balbach Smelting & Refining Co.	Bb,[a] NBC.
Calumet & Hecla Mining Co.	C & H M Co
Copper Range.	C R
Nichols Copper Co.	N L S, R M C
Phelps, Dodge & Co.	C Q, P D C [a]
Quincy Mining Co.	Q M Co
Raritan Copper Works.	N E C
Tamarack & Osceola.	T M Co
Tennessee Copper Co.	T C C [a]
United States Metals Refining Co.	D R W

COPPER SOLD ON CONTRACT.

Most of the copper sold in this country is sold on contract, buyers usually contracting for a period of two to four months, except when the condition of the market is such that decidedly lower prices are expected. The quantity of copper in warehouses in New York is comparatively small, so that large orders for immediate delivery can not usually be placed. Sometimes refineries have considerable stock on hand, but of course it is not desirable for them to carry large unsold stocks. It is the universal custom of the selling agencies in quoting prices on contracts to specify a price on copper delivered at the buyer's works, cash to be paid in 30 days. It makes no difference where the copper is delivered, the selling agency taking care of the freight.

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[a] Casting.

POINTS OF CONSUMPTION OF COPPER.

Most of the copper from the vicinity of New York is used near the Atlantic coast, especially in the Naugatuck Valley of Connecticut. Other important isolated centers are Trenton, N. J., Rome, N. Y., Pittsburgh, Pa., and Detroit, Mich. Copper marketed in New York but used at Detroit or elsewhere in the West has to stand a freight charge from New York, which is paid by the selling agency. For this reason western demand is filled almost entirely by the western refineries at Great Falls, Mont., and Tacoma, Wash., and by Lake copper, which is shipped direct from Michigan.

FREIGHT RATES AND SELLING PRICE.

The freight rate from the principal refineries about New York to the manufacturing centers ranges from about 1 cent to 18 cents per hundred pounds. A large part of the copper shipped from the vicinity of New York is charged a freight rate of about 12 cents per hundred pounds, which may be considered the average freight expense. In selling to Europe, the average cost to the seller delivering copper to regular ports is about 17½ cents, which includes freight, insurance, and banking expense. When the privilege of paying cash in 30 days is not used, a discount of 0.5 per cent is often allowed. Hence the net cash equivalent, New York, of a sale "delivered 30 days" is about 12½ to 20 cents per hundred pounds less than the price quoted to the manufacturer. The daily market price, as quoted, for instance, in the "Engineering and Mining Journal," is on that basis, that is, cash for copper in New York. The market price is based on the bulk of the transactions recorded for the day. It is evident that, as there is no open market such as an exchange would create, this price may not represent all of the transactions that have taken place. However, the various agencies, by means of extensive organization and constant intercourse with buyers, keep thoroughly posted as to sales, thus effecting practically the same conditions that an open market would create.

ZINC OR SPELTER.[a]

The common term for commercial zinc is spelter. The main market or basing point for spelter is St. Louis, Mo., for the reason that the great zinc fields and a large number of the smelting plants for zinc are situated not far from St. Louis. However, the large consumption of spelter is at places between St. Louis and New York, and it is sold in New York on a St. Louis basis.

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[a] See Ingalls, W. R., How the metals are sold—spelter: Eng. and Min. Jour., vol. 94, Oct. 26, 1912, pp. 789–790.

The New York price is the St. Louis price plus 15 cents per hundred pounds, which is the freight rate on spelter from St. Louis to New York. The American market is in part independent of the European market, because spelter is protected by an import duty of 15 per cent ad valorem and zinc in ore by a duty of 10 per cent ad valorem.

CAPACITY OF ZINC-SMELTING PLANTS.

Zinc ore is produced by a large number of small mines and sold to smelting works which are numerous and independent of each other, so that the competition for ore is keen. The accompanying table gives the names of the smelting works that control the zinc output and their capacity.

Capacity of zinc-smelting plants in the United States.[a]

[Number of retorts at end of year 1914.]

Name of plant.	Situation.	
Altoona Zinc Smelting Co	Altoona, Kans	[b] 3,845
American Zinc & Chemical Co	Langeloth, Pa	864
American Zinc Co. of Illinois	Hillsboro, Ill	400
American Zinc, Lead & Smelting Co	Dearing, Kans	3,840
Do	Caney, Kans	[b] 3,648
Bartlesville Zinc Co	Bartlesville, Okla	5,184
Do	Collinsville, Okla	8,064
Chanute Zinc Co	Chanute, Kans	[c] 1,280
Clarksburg Zinc Co	Clarksburg, W. Va	2,712
Collinsville Zinc Smelting Co	Collinsville, Ill	[b] 1,536
Edgar Zinc Co	St. Louis, Mo	1,100
Do	Cherryvale, Kans	4,800
Granby Mining & Smelting Co	Neodesha, Kans	3,840
Do	East St. Louis, Ill	3,240
Grasselli Chemical Co	Clarksburg, W. Va	12,672
Do	Meadowbrook, W. Va	
Hegeler Bros	Danville, Ill	1,800
Illinois Zinc Co	Peru, Ill	4,640
La Harpe Spelter Co	La Harpe, Kans	1,856
Robert Lanyon Zinc & Acid Co	Hillsboro, Ill	1,840
Lanyon-Starr Smelting Co	Bartlesville, Okla	3,456
Matthiessen & Hegler Zinc Co	La Salle, Ill	5,256
Mineral Point Zinc Co	Depue, Ill	9,080
National Zinc Co	Bartlesville, Okla	4,260
Do	Springfield, Ill	3,200
Nevada Zinc Co	Nevada, Mo	[c] 648
New Jersey Zinc Co	Palmerton, Pa	5,760
Pittsburg Zinc Co	Pittsburg, Kans	[b] 910
Prime Western Spelter Co	Gas City, Kans	4,768
Sandoval Zinc Co	Sandoval, Ill	6,896
Tulsa Fuel & Manufacturing Co	Collinsville, Okla	4,232
Tulsa Spelter Co	Sands Springs, Okla	4,000
United States Zinc Co	Pueblo, Colo	1,920
Total		120,994

[a] Engineering and Mining Journal, Zinc production in 1914: vol. 99, Jan. 10, 1915, p. 63.
[b] Inactive during latter part of year.
[c] Inactive.

CHARACTER OF THE ZINC MARKET.

In the marketing of zinc, it is customary for the producer to sell direct to the manufacturer. This policy, however, in in view of the large number of producers, is not nearly so closely followed as in the selling of copper, and some of the producers, particularly the smaller ones, sell to anyone who cares to purchase. This condition of course gives rise to more speculation in zinc than in copper. The real spelter market is established by the private transactions of producer and consumer, and any information as to the state of the market can come only from them. The facilities for exchanging information in the spelter market are not as good as those in the copper market, and hence transactions between producer and manufacturer often show considerable difference in price.

FOUR KINDS OF SPELTER.

There are four kinds of spelter on the market, the names of which, with the permissible proportions of impurities are given in the accompanying table:

Grades of spelter.[a]

Designation.	Proportion of lead.	Proportion of iron.	Proportion of copper.	Total proportion of impurities.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
A or high-grade	0.07	0.03	0.05	0.10
B or intermediate	.20	.03	.05	.50
C or brass special	.75	.04	.75	1.20
D or prime Western	1.50	.08	....	....

[a] Each grade to be free from aluminium.

The grade produced in largest amount is prime Western, a considerable part of which is used for galvanizing iron and steel wire and iron plate. Brass special is used chiefly in the manufacture of brass goods. The price of high-grade spelter is usually 2 to 4 cents per pound more than that of prime Western. Intermediate spelter is 1 cent to 2 cents more per pound, whereas brass special is 5 to 25 cents more per 100 pounds than prime Western. The high-grade and intermediate spelters are made by only a few smelters, but the brass special and prime Western are made by many concerns.

LEAD.

ENTIRE OUTPUT USED IN UNITED STATES.

The United States uses its entire lead production, and in fact imports some lead. Thus, in 1912, the refinery statistics show the production of 497,724 tons of lead, of which 87,718 tons was of foreign origin. Of this foreign lead, 64,905 tons was again exported, leaving as the actual imports about 18,655 tons.

Under the old tariff lead was protected by a duty of 70 per cent ad valorem, and the market in the United States was practically independent of the rest of the world. However, the new tariff reduced this tax to 25 per cent ad valorem, which tends to make the American lead market much less independent and apt to be influenced by foreign markets.

LEAD PRODUCED LARGELY BY FOUR COMPANIES.

By far the greater part of the lead in this country is produced by four large companies, the American Smelting & Refining Co., the United States Smelting, Refining & Mining Co., the International Smelting & Refining Co., and the St. Joseph Lead Co. Other concerns produce lead in smaller quantity. In 1912 one of the large companies named produced more than 75 per cent of the total lead output of the United States, and in that year the United States produced 30.7 per cent of the world's production.

THREE COMMERCIAL FORMS OF LEAD.

Lead is placed on the market in three forms, as follows: (1) As ordinary refined lead; (2) as corroding lead, used in the manufacture of pigments, and of necessity especially pure, one of the qualifications being that it shall be practically free from bismuth (corroding lead usually brings a premium above ordinary refined lead); (3) as antimonial lead, an impure lead containing antimony and used largely in type metal. The average composition of antimonial lead is: Lead, 81 per cent; antimony, 17 per cent; other metals, 2 per cent. Lead is marketed in the typical pigs or bars, weighing approximately 80 pounds each.

Lead is used in making the following products, the figures given being for 1909:

Products made from lead in 1913.

Product.	Proportion of total production.
	Per cent.
Pigments, white lead, red lead, litharge, orange mineral	38.0
Lead pipe	15.2
Lead sheets	6.7
Shot	10.4
Other products, such as type metal, solders, and alloys	29.7

FACTORS AFFECTING PRICE OF LEAD.

The basing points for lead are New York and St. Louis. The difference in price between the two points is usually about 15 cents, or the freight rate per 100 pounds. Thus, if lead in New York is 4 cents it will be 3.85 cents in St. Louis. However, the two markets sometimes approach each other, owing either to speculation or to special conditions, such as temporarily curtailed production in the Missouri lead fields. The "Engineering and Mining Journal" quotes every week a price on lead based on wholesale transactions for good, ordinary brands. The figure represents the New York cash price. The American Smelting & Refining Co. makes an official "quotation," which is called the "sales price." This is usually changed 12 to 14 times per year, as the rise or fall of the market may demand. This sales price is in effect the figure at which the company will sell its lead. The open market is sometimes above and sometimes below this figure.

In the past 10 years, before the new tariff went into effect, the average difference in price of lead between New York and London, which is the chief foreign market, was about 1½ cents per pound. With a duty of 70 per cent this difference was insufficient to cause the importation of foreign lead. However, with the new duty of only 25 per cent it can readily be seen that foreign lead might be imported under certain conditions. In Europe there is in existence the International Sales Association, which was first formed in Paris in 1909. This is composed of the German, English, Spanish, and Belgian producers and selling agencies and those American and Australian producers that consign to Europe. The American interests in this association are small. The association was formed to assign selling spheres to different interests and to steady prices.

PUBLICATIONS ON MINERAL TECHNOLOGY.

A limited supply of the following publications of the Bureau of Mines is temporarily available for free distribution. Requests for all publications can not be granted, and to insure equitable distribution applicants are requested to limit their selection to publications that may be of especial interest to them. Requests for publications should be addressed to the Director, Bureau of Mines.

Bulletin 3. The coke industry of the United States as related to the foundry, by Richard Noldenke. 1910. 32 pp.

Bulletin 12. Apparatus and methods for the sampling and analysis of furnace gases, by J. C. W. Frazer and E. J. Hoffman. 1911. 22 pp., 6 figs.

Bulletin 47. Notes on mineral wastes, by C. L. Parsons. 1912. 44 pp.

Bulletin 53. Mining and treatment of feldspar and kaolin in the southern Appalachian region, by A. S. Watts. 1913. 170 pp., 16 pls., 12 figs.

Bulletin 54. Foundry cupola gases and temperatures, by A. W. Belden. 1913. 29 pp., 3 pls., 16 figs.

Bulletin 64. The titaniferous iron ores in the United States, their composition and economic value, by J. T. Singewald, jr. 1913. 145 pp., 16 pls., 3 figs.

Bulletin 70. A preliminary report on uranium, radium, and vanadium, by R. B. Moore and K. L. Kithil. 1913. 100 pp., 2 pls., 2 figs.

Bulletin 71. Fuller's earth, by C. L. Parsons. 1913. 38 pp.

Bulletin 81. The smelting of copper ores in the electric furnace, by D. A. Lyon and R. M. Keeney. 1914. 80 pp., 6 figs.

Bulletin 84. Metallurgical smoke, by C. H. Fulton. 1915. 94 pp., 6 pls., 15 figs.

Technical Paper 15. An electrolytic method of preventing corrosion of iron or steel, by J. K. Clement and E. V. Walker. 1913. 19 pp., 10 figs.

Technical Paper 31. Apparatus for the exact analysis of flue gas, by G. A. Burrell and F. M. Seibert. 1913. 12 pp., 1 fig.

Technical Paper 36. The preparation of specifications for pretoleum products, by I. C. Allen. 1913. 12 pp.

Technical Paper 41. The mining and treatment of lead and zinc ores in the Joplin district, Mo.; a preliminary report, by C. A. Wright. 1913. 43 pp., 5 figs.

Technical Paper 50.—Metallurgical coke, by A. W. Belden. 1913. 48 pp., 1 pl., 23 figs.

Technical Paper 54. Errors in gas analysis due to assuming that the molecular volumes of all gases are alike, by G. A. Burrell and F. M. Seibert. 1913. 16 pp.

Technical Paper 58. Action of acid mine water on the insulation of electric conductors, a preliminary report, by H. H. Clark and L. C. Ilsley. 1913. 26 pp., 1 fig.

Technical Paper 60. The approximate melting points of some commercial copper alloys, by H. W. Gillett and A. B. Norton. 1913. 10 pp., 1 fig.

Technical Paper 81. The vapor pressure of arsenic trioxide, by H. V. Welch and L. H. Duschak. 1915. 21 pp., 3 pls., 2 figs.

Technical Paper 95. Mining and milling of lead and zinc ores in the Wisconsin district, Wisconsin, by C. A. Wright. 1915. 39 pp., 2 pls., 5 figs.